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BARN AND FIELD EXPERIMENTS IN 1917.

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† In collaboration with U. S. Department of Agriculture.

BULLETIN 269

BARN AND FIELD EXPERIMENTS IN 1917.

REPORTED BY CHAS. D. WOODS.

The work of investigation at the two Experiment Station farms (Aroostook Farm, Presque Isle, and Highmoor Farm, Monmouth) is planned by the Director, the Biologists, the Plant Pathologist and the Entomologist. The results of the more scientific phases of the studies are reported from time to time in the bulletins, but it always happens that there are results obtained that lie somewhat outside of the lines of work of any of the Station specialists. Some of the more popular and practical results are here reported. The carrying out of these experiments and the taking of the requisite notes devolved upon different members of the Staff.

ARE SWINE PROFITABLE IN WINTER?

In the winter of 1915-16 an experiment was undertaken on the care of manure. This was reported in Bulletin 260. In that experiment it was necessary to keep the manure well worked over and at the same time compacted so as to prevent losses from heating. As it was thought that swine might do this work at a less cost than for man labor, pigs were kept upon the manure. An exact account of feed and time for care was made and it was found after making allowances for certain unusual losses that the swine had been kept at a profit of about 15 per cent on the total investment. As the manure pit was maintained in the same way in the winter of 1916-17 an account of income and out go was kept as follows:

November 5, 1916, 16 eight weeks old pigs were purchased for $3 each, placed upon the manure and kept there until they were sold May 21, 1917. The swine were fed and handled as

the superintendent found convenient. In general the swine were fed cooked turnips with adition of ground feed. Corn on the cob was occasionally thrown over the manure to keep the swine at work stirring the manure. During the little over 6 months the swine were fed 600 pounds of small cull potatoes, 9130 pounds of turnips, 1375 pounds of middlings, 1030 pounds of corn meal, 300 pounds of soy bean meal and 2090 pounds of corn on the cob. This corn on the cob included the soft ears and nubbins and smaller ears after the better part of the corn had been selected for seed. It took about 15 minutes a day to feed and care for the swine and from one to two hours a week to cook the mash. The total time spent on the care and feeding was 85 hours. The food used cost $121.80. The cost of the labor was $17.50. These items added to the purchase price ($48.00) of the pigs made the entire cost $187.30. The pigs at the end of the experiment were sold for $218.40 leaving a cash income balance of $31.10. The value of the manure was sufficient to more than meet any charges for investment and upkeep. Based on the cost of the pigs the percentage gain was 65 per cent. Based upon the total cost it was a little over 15 per cent.

Beside being directly profitable swine materially improve farm manure, particularly that dropped by horses and sheep. It is a conservative estimate that the plant food annually voided by farm animals and poultry in Maine has a potential value of about $10,000,000 dollars, and it is doubtful if by present methods of care one-half of this plant food actually finds its way back to the soil. The trials reported last year in Bulletin 260 with the manure platform and swine indicate that by a little care most of this plant food can be saved. In the 2 years that the platform has been used the swine have made a good return on the investment and the added plant food saved was all clear profit. And in many instances this conserved plant food will be the difference between keeping live stock at a profit or keeping them at a loss.

ARE SHEEP PROFITABLE IN MAINE?

The Station Council, at its meeting in April 1914, authorized the purchase of grade sheep sufficient to stock Highmoor Farm for the purpose of studying the question as to whether sheep can or cannot be profitably raised in Maine. The sheep were not to be of a fancy type, or be pure bred so that none of the animals could be sold at a fancy price. Nor were they to be early bred to produce "hot house" lambs for the high price of the early market. They were to be just plain sheep such as any ordinary farmer could carry. While care was to be exercised in handling the sheep, no high priced labor was to be used. Nor was a special "shepherd" to be employed.

The sheep are grade Hampshire, but are so nearly pure Hampshire that only an expert could tell them from pure bloods. They are as fine a flock of sheep as one cares to see. The farm superintendent is an experienced man with sheep and they have excellent care. Two years ago the results of the first year's trial were published in Bulletin 246. This trial showed that the sheep were kept at a large loss. This publication led to the receipt of many letters and to the publication of some newspaper articles. It was evident from these that many owners thought they were making money from sheep. But no one was found who was keeping a flock of about 100 sheep who knew from actual figures whether they were or were not being kept at a profit. At the recent convention of the State Dairymen's Association a paper was read that showed a profit on a small flock, but many of the data cited were estimates.

It is probably true that on most farms a few sheep would be profitable, because they would be cared for in time that otherwise would not be profitably employed, and the sheep would be fed more or less of unmarketable produce and hay. A set of books in which everything was charged and credited would probably not show the balance on the credit side. Nevertheless, most farmers who are equipped for them would be better off with a few sheep, because of the salvage of time and materials that might otherwise be wasted. Thus with sheep it is the same as it is in the case of a few swine, a small flock of hens, a small area devoted to garden crops, etc. With certain

well known exceptions, very few of the farm items, charging labor at what it costs, food at what it is worth, and taking fixed charges into account, would show book profit. Nevertheless, on every hand there are farmers who with incomes derived from small flocks, small herds, and small areas devoted to crops, live comfortably, educate their children, and accumulate some bank surplus.

There will always be an expense for fitting up and maintaining pastures, buildings, etc., for sheep that will vary on different farms and with different farmers. The overhead charges, such as interest, taxes, and the like, will also vary with varying conditions. In an experiment conducted by the Station, where it is necessary to keep individual records, buttons for the ears and time involved in note taking are expense items that the ordinary farmer need not be at. For these and similar reasons the cost of fencing the pastures, erecting shelters in the pastures, fitting up the barns for winter quarters, expenses for piping water, water troughs, sheep dipping tanks, shearing machine, gas engine, root cutter, rent of land for pastures and crops for the sheep, while necessary expenses that must be taken into account by the practical farmer, are omitted from the following statement. The amounts included are the inventory value of the sheep, the cost of labor in caring for the sheep, cost of food purchased, the value of the hay and straw at the barn, the cost to grow the roots used. The credits are the sheep and wool sold and the inventory at the end of the year.

As reported in Bulletin 246, the year as given ran from July 1 to June 30. This is the fiscal year as prescribed by the State Auditor, but is not a good one for an experiment of this kind which far more naturally begins and ends either with turning the sheep out to pasture in the spring, or, still better, with the housing of the sheep in the fall. In order to make it possible to include practically all the income from the sheep within the year, the duration of the year is changed so that it now runs for 12 months from the first of November, instead of the first of July. In order to compare fairly the first report as given has been changed so as to make it begin November 1, 1914, instead of July 1, 1914, as it was previously reported.

The results of the experiment for the years 1914-15 and 1915-16 are reported in Bulletin 260 of this Station. The receipts and expenditures for 1916-17 follow.

Sheep Account for year Nov. 1, 1916 to Oct. 31, 1917.

Inventory and Expenditures.

38 original purchase ewes 7 1914 ewes 22 1915 ewes	67 at $5	$335.00	
20 1916 ewe lambs at $3		60.00	
2 registered Hampshire bucks		50.00	
1 Hampshire buck obtained in exchange for 2 ewe lambs		6.00	
1 pure bred Hampshire buck in exchange for lamb		25.00	
1 pure bred buck		35.00	
Hay, 40,200 pounds at $10 per ton		201.00	
Rowen 13,600 pounds at $8 per ton		54.80	
Straw 2150 pounds at $6 per ton		6.45	
Bran and mixed feed 6000 pounds at $1.80 per cwt.		108.00	
Corn meal, 1400 pounds at $2.25 per cwt.		31.40	
Oats 600 pounds at $2.15 per cwt.		12.90	
Turnips 41,800 pounds at cost of growing		102.00	
Rape and cost of growing		20.00	
Salt 2 bushels		.80	
20 gallons gasoline at 28 cents		5.60	
552 man hours at 20 cents		110.40	
10 horse hours at 15 cents		1.50	$1165.85

Receipts and Inventory.

Wool 548 ½ pounds 65 cents		356.53	
Pelts		3.60	
Sheep and lambs sold		421.61	
23 original purchase ewes 7 1914 ewes 19 1915 ewes 16 1916 ewes	65 head at $5	325.00	
30 1917 ewe lambs at $3		90.00	
3 rams at $30, $35, $40.		105.00	
Manure 40 tons with swine, 9 tons from sheep barn, 10 tons from summer sheds		*	
			$1301.74

*Value not included. See discussion in text.

THE FLOCK DURING THE YEAR.

When the sheep were put into their winter quarters the first of November, 1916 there were 90 head consisting of 38 of the original purchase ewes, 7 ewes born in 1914, 22 ewes born in 1915, 20 ewe lambs of the spring of 1916 and 2 thorough bred Hampshire rams and 1 Hampshire buck lamb. The 67 ewes gave birth to 79 lambs of which 74 were vigorous and were raised. During the year, and chiefly in the spring 10 of the older ewes died. Two died in lambing, 2 from grub in the head and 6 from undetermined causes. The general health of the flock was excellent. The sheep that died were in poor flesh and lacked in bodily vigor. The clip averaged 6.3 pounds for the flock, ewes, ewe lambs and rams. It was sold for 65 cents a pound.

The buck lamb obtained in the fall of 1916 in exchange for 2 ewe lambs was not promising as breeding stock and was sold for slaughter. One of the old rams had been lacking in vigor since the winter of 1916-17 and died in June. Two full blooded Hampshire rams were purchased. One of these cost $35 and the other was bought for $25 and a ram lamb. This is the one inventoried at $40. During the year 58 head were sold. At the close of the year, October 31, 1917, 98 head were put into winter quarters. The flock at that time consisted of 23 of the original purchase ewes, 7 ewes born in 1914, 19 born in 1915 and 16 born in 1916—65 ewes in all—30 ewe lambs born in 1916 and 3 full blooded Hampshire rams.

THE EXPENDITURES.

The inventory of the flock is at a much lower price than they could be purchased for or than they would be sold for. This bears only slightly on the experiment as the numbers of the sheep are kept fairly constant year after year. Rather more sheep were carried through the winter of 1915-16 than would usually be the case.

No account is taken of the feed consumed from the 3 pastures aggregating about 100 acres. Nor is rental charged for land used in growing crops such as rape and turnips for the use of the sheep. The concentrated feeds are charged at

about the average cost for each year, but this does not include freight or cartage. The hay and straw are priced at what they would have sold for at the barn each year. The turnips and rape are charged at what it costs to grow them without any overhead charges.

The only labor charged against the sheep is the actual time used in care, as feeding, shearing, etc. The work of keeping up pasture fences, buildings, making records, and other things incident to the experimental side that does not directly apply to the sheep, is not included in the tabulation.

Receipts.

The wool and lambs sold each year were probably as well marketed as the average farmer could expect unless he put a good deal of his own time (and in the case of the Station that means added cost) into finding a market. With the constantly advancing price of wool it might have been held and likely later have been sold at a higher price. But that would not have been part of the experiment. It would be speculation as is all holding of crops for a better market. No attempt to market in any unusual way was made as that would be contrary to the plan of the experiment.

The manure from the sheep at the barns weighed 48 tons and that from the summer droppings in the pasture houses about 12 tons. As pointed out in Bulletin 260 the common practice of keeping the droppings under the sheep during the winter is wasteful. The manure is best removed at intervals of about a month and put under swine. It is difficult to at all accurately estimate the value of the manure. From this number of sheep handled as indicated above, the manure produced is worth at present prices of nitrogen, phosphoric acid and potash from $250 to $300 a year. This is not included in the receipts from the sheep. It is allowed as an offset to the overhead charges which as stated above are not included in this account with sheep.

The marked increase in value of the sheep since the experiment began is not taken into account as it is "an unearned increment" and is no part of the experiment.

THE THREE YEAR RESULTS.

If any farmer had started with a flock of about 100 sheep at the time this experiment was begun the marked advance in the value of the flock would have made the venture a profitable one. But the same would have been true if he had invested a like sum of money in any one of numerous commodities that have been advancing in price at leaps and bounds. While viewed from that standpoint the balance is on the right side of the ledger from the standpoint of sheep production alone the 3 years are still behind. The loss the first year was (without taking manure into account) $375, and $200 the second year. This year there is a credit balance of $135. The differences in values of hay in the different years largely accounts for the differences in the cost of the food consumed in the different years. If hay had been worth in 1916-17 $15 a ton as it was the year before the sheep would have about broken even. With the low price of hay the present year, unless some unexpected reasons cause marked falling off in price of mutton and wool, the sheep should show a profit.

Without taking into account the profit that came from the increased value of the sheep during the year, a man who had handled a flock of 100 sheep for profit in 1916-17 would have found a market for his hay at $15 a ton, kept the plant food in the hay on his farm, had 20 cents an hour for the time spent in care of the sheep and the approximately $250 worth of manure for rent of land, upkeep of buildings and fences, interest on investment and other overhead charges. Or reckoning the hay at its market value of about $10 a ton in the barn, by feeding it to the sheep he would have received about 45 cents an hour for the time given to their care.

FERTILIZER EXPERIMENTS ON APPLE TREES AT HIGHMOOR FARM.

As it is pretty generally known, when the State purchased Highmoor Farm it had something over 3,500 apple trees upon it. These trees were about 25 years old, but for the most part had been completely neglected, as regards pruning, fertilization, culture and spraying. The first season that the Station had the farm the orchards were plowed, cultivated and sprayed. Pruning was begun and has been continued until at the present time the orchards are in pretty fair shape. It was, of course, not desirable or practical to thin the trees out at the start to where they should be at the end, but the pruning while rather severe each year has been gradually decreased in amount. The trees are well cared for by spraying for insects and fungi.

The orchards were annually fertilized at the rate of 1,000 pounds per acre of a commercial fertilizer carrying 5 per cent of ammonia, 8 per cent of available phosphoric acid and 7 per cent potash. At the end of the third year the orchards had so far responded that they gave a good crop and since that time fertilizer experiments have been carried on in various portions of the orchards, as follows:

Nitrogenus Fertilizer Experiment.

The use of highly nitrogenous fertilizers has been advocated as a means of forcing trees into bearing and in some parts of the State has been tried with results that seemed to be gratifying. This method was first suggested by Doctor Fisher of Massachusetts and was tried by the Station several years ago in cooperative work with Mr. Pope in his orchard at Manchester without very decisive results. At Highmoor Farm a row of 32 Baldwin trees was divided into 3 sections. The trees were treated alike so far as the application of standard fertilizer was concerned, but 10 of the trees at each end of the row received in addition nitrate of soda at the rate of 100 pounds per acre. Also the Baldwin orchard was divided into 2 parts so that part of it received the usual treatment and in addition received 100 pounds of nitrate of soda per acre per year.

Exact records of yields and measurements of growth have been taken since the experiment was begun. No differences that could be attributed to the additional nitrogen in the fertilizer have been observed. It may be that when at the end of a period of years the data are carefully analyzed, results may be found that are not noticeable from general observations. The experiment is being continued.

EXPERIMENT IN BEN DAVIS ORCHARD NO. 1.

In experiments carried out at the New York State Experiment Station it was found that with their deep clay soils well suited to apple tree growth and apple bearing, there is no effect from the use of fertilizers either upon the growth of young trees, the wood growth on matured trees, or in the amount, coloring, or size of the fruit. To see if anything like this would hold with Maine conditions, particularly with the rather shallow soil and with the stubborn subsoil upon Highmoor Farm, an experiment was begun in 1912. It is to be remembered that the orchard had been cultivated and fertilized for the 3 preceding years and brought into good condition. About 400 trees were divided into 3 plots containing 12 rows extending clear across the large No. 1, Ben Davis orchard. Plot A (rows 1 to 4) has received no fertilizer since 1912. Plot B (rows 5 to 8) has received annually since 1912, 500 pounds per acre of a fertilizer carrying 4 per cent of nitrogen, 8 per cent of available phosphoric acid and 7 per cent of potash. Plot C (rows 9 to 12) has received annually since 1912, 1,000 pounds per acre of a commercial fertilizer carrying 4 per cent of nitrogen, 8 per cent of available phosphoric and 7 per cent of potash. The trees are spaced 25 feet by 25 feet and this amount of fertilizer is therefore at the rate of about 7.2 pounds in Plot 6 B and 14.2 pounds in Plot 6 C per tree.

TYPES OF TREES IN FERTILIZER EXPERIMENT AT HIGHMOOR FARM.

The records of the yields of the trees in the fertilizer experiment show that there are some trees in each of the plots that have never failed to bear heavy crops and others that have never failed to be light yielders. The Station has no information as to the reason for the differences but in the part of the

orchard in the fertilizer experiment there are at least 3 distinct types of trees.

Type 1 is a tree having a stocky appearance with the head made up of large limbs bearing many fruit spurs. Type 3 is a tree having no large main branches but with the head made up of many long slender limbs with the bearing wood mostly at their ends. Type 2 is a tree having a head that is intermediate between type 1 and type 3.

In plot 6 A. during a 4 year period there were 2 trees that were consistently heavy yielders and both were of type 1. In the same plot were 8 trees that were consistently low yielders of these 7 were of type 3 and 1 of type 2. *In plot 6 B.* for the same period there were 4 consistently high yielding trees 1 of which was of type 1 and 3 of type 2. In the same plot were 6 low yielding trees all of type 3. *In plot 6 C.* for the same period there were 9 high yielding trees all of type 1 and 5 low yielding trees all of type 3.

For these or similar reasons the following trees are not considered in the discussion of results here reported.

Row	1	trees	1, 2, 6, 7, 14, 18, 29, 33.
"	2	"	3, 7, 22, 23, 36.
"	3	"	1, 5, 7, 22.
"	4	"	5, 6, 8, 12, 19, 24, 31, 33.
Row	5	trees	3, 4, 9, 27, 28, 29, 33.
"	6	"	1, 2, 4, 12, 17, 23, 35.
"	7	"	1, 9, 10, 11, 25, 32, 33, 36.
"	8	"	1, 2, 9, 23.
Row	9	trees	1, 2, 3, 5, 8, 10, 22, 24.
"	10	"	3, 14, 20, 21, 24, 29, 30, 31, 33, 34.
"	11	"	1, 17, 30, 33.
"	12	"	4, 5, 31, 32, 33, 34.

CULTIVATED PLOTS AND PLOTS IN GRASS.

On all of the plots up to the summer of 1916 rye was sown in the late summer as a cover crop. This was plowed under early in the spring and the land was kept cultivated until August when the new cover crop was again sown. On the west half (cultivated plots) this practice is continued. On the east half (plots in sod) the grass is cut and applied as a mulch. The plant food stored up in the wood growth and that which is removed in the apple crop is taken from the soil, but

beyond that the soil is not asked to pay tribute to any crop removed from the plots.

In the following tables the western half of each plot is designated as cultivated plot and the eastern half as plot in grass. The plot in grass was really not in sod until 1917 previous to which, it was under cultivation the same as the other plots. The yields for the 4 years are given in the table that follows. In the upper portion of the table the parts cultivated and in sod are reported separately and in the lower portion the results are combined to show the average yields from the different fertilizer treatments.

Table Giving the Yields of Apples in Pounds Per Tree for Each Plot and Each Treatment for 4 Years.

Year	PLOT 6 A No fertilizer since 1912		PLOT 6 B 7.2 pounds 5-8-7 fertilizer per tree		PLOT 6 C 14.4 pounds 5-8-7 fertilizer per tree	
	Cultivated	In grass	Cultivated	In grass	Cultivated	In grass
1914	165.4	198.0*	145.9	179.6*	186.6	203.1*
1915	118.6	131.5*	134.9	149.0*	145.6	162.0*
1916	105.9	127.3*	141.2	137.6*	155.9	129.8*
1917	117.7	127.6	72.2	80.2	79.6	75.6
Average	126.9	146.1	123.6	136.6	141.9	142.6
	Both Parts		Both Parts		Both Parts	
1914	183.2		164.2		194.5	
1915	125.6		142.6		153.5	
1916	117.6		139.2		142.4	
1917	123.1		76.5		77.7	
Average	137.4		130.6		142.0	

*These were cultivated in years 1914, 1915, and 1916. Seeded to grass in August 1916.

As the parts in grass had been seeded only a single season the slight differences in yields between the cultivated parts of the plots and the parts in grass for the year 1917 are not discussed.

The interest therefore lies in the last half of the table in which the average yields from the trees in the differently fertilized plots are shown. The yields for 1913, the first year after the different fertilizer treatment began, are omitted. In the second year (1914) no differences that can be attributed to the fertilizing appear. In 1915 and 1916 there is a small but constant difference in favor of the fertilized plots. The yield increases with the amount of fertilizer applied. But in 1917

the yields for the fertilized plots dropped 40 per cent below the yields for the plot without fertilizer for the 4 years. Row 1 in Plot A, no fertilizer, has an open field on its north. It was thought that possibly this might have borne unusually heavy and explain the no fertilizer plot having the far larger yield. The table that follows shows the yield per tree in each row. The sharp falling off in yield from Row 4 of Plot 6 A to Row 5 Plot 6 B continues through all the other rows in Plots 6 B and 6 C.

Average Yields in Pounds per Tree by Rows in 1917.

Plot 6A No Fertilizer		Plot 6B 7.2 pounds Fertilizer		Plot 6C 14.4 pounds Fertilizer	
Row	Yield	Row	Yield	Row	Yield
1	137.8	5	93.7	9	88.6
2	120.1	6	74.7	10	79.9
3	118.3	7	68.9	11	78.1
4	113.9	8	69.2	12	65.2
Avg.	123.1	Avg.	76.5	Avg.	77.7

There is no doubt as to the fact, but the explanation of the fact is not evident. If the marked difference had been in favor instead of against the fertilizer plots or if the season had been deficient in rainfall so that the fertilizer might not have been available to the trees an explanation would suggest itself. There are too many trees in the experiment and the differences are too great, too marked and too uniform to be classed as coming within ordinary experimental error.

Sod vs. Cultivation.

The east half of the plots have been in sod only 1 year and it is too soon to look for any marked difference due to the treatment. As full growth notes are kept on all trees at Highmoor Farm the records of the size of the apples and their color for 1917 in which part of the plots have been in sod are tabulated below. For the sake of comparison the same notes are given for the 2 years before the east half was seeded to grass.

Table Giving the Number of Trees in Each Plot that Yielded Fruit of Large, Medium and Small Size for the 3 Years.

Plot and Year	Cultivated Part			Part in Grass		
	Large	Medium	Small	Large	Medium	Small
Plot 6A						
1915	52	0	0	65	0	0 } Cultivated
1916	33	21	0	24	41	0 } Cultivated
1917	10	32	12	10	39	16 In Grass
Plot 6B						
1915	53	0	0	62	0	0 } Cultivated
1916	24	28	1	41	19	2 } Cultivated
1917	0	27	26	2	26	35 In Grass
Plot 6C						
1915	56	0	0	50	0	0 } Cultivated
1916	48	7	1	41	9	1 } Cultivated
1917	45	9	1	0	16	35 In Grass

Table Giving the Number of Trees in Each Plot that Yielded Fruit of Good, Medium and Poor Color for the 3 Years.

Plot and Year	Cultivated Part			Part in Grass		
	Good	Medium	Poor	Good	Medium	Poor
Plot 6A						
1915	3	48	1	10	55	0 } Cultivated
1916	5	45	4	28	36	1 } Cultivated
1917	21	32	1	55	10	0 In Grass
Plot 6B						
1915	1	52	0	4	58	0 } Cultivated
1916	15	38	0	6	56	0 } Cultivated
1917	44	9	0	61	1	1 In Grass
Plot 6C						
1915	15	41	0	27	23	2 } Cultivated
1916	2	54	0	4	47	1 } Cultivated
1917	4	51	9	50	1	0 In Grass

Although the results from a single year's trial are not at all conclusive it is interesting to tabulate the results in a way that quite sharply points out any differences that do exist. In the following table this is done by weighing the results. The small in size, poor in color are considered as the unit. The medium in size or color are considered to have twice and the large in size or good in color 3 times the value of the small or poor. If one adds these values together and divides by the number of trees the following results are obtained.

Comparison of Grass and Cultivtaed Parts of the Plots.

The "part in grass" was really in cultivation in 1915 and 1916.

Plot and Year	Cultivated part		Part in grass		Part in grass compare with cultivated part	
	Size	Color	Size	Color	Size	Color
Plot 6A						
1915	300	204	300	216	0	+12
1916	246	202	237	242	— 9	+40
1917	196	237	191	285	— 5	+48
Plot 6B						
1915	300	202	300	207	0	+ 5
1916	243	228	261	210	+ 18	—18
1917	151	283	148	295	— 3	+12
Plot 6C						
1915	300	227	300	248	0	+21
1916	284	204	263	206	— 21	+ 2
1917	280	244	148	298	—132	+54

For the one year in grass there is a reduction in size and improvement in color as compared with the cultivated parts. In all the years there seems to be striking correlation between size and color. The larger the size of the fruit the poorer the color, and the smaller the fruit the better the color seems to be the rule.

It is planned to continue the experiment until decisive results are obtained and the unfertilized plot shows evidence of the need of plant food.

COMMERCIAL VARIETIES OF OATS GROWN AT HIGHMOOR FARM IN 1917.

The Maine Agricultural Experiment Station has been conducting tests of commercial varieties of oats at Highmoor Farm since 1910. The detailed results of these tests for the 4 years 1910 to 1913 inclusive were published in Bulletin 229, the results of the 1915 tests were published in Bulletin 246, and the results for 1916 in Bulletin 260.

The season of 1916 was very unfavorable for oats at Highmoor Farm and the yields were the lowest obtained since the Station has had the farm. The season of 1917 was unfavorable for even stands and good yields. The yields for 1917 are given in the table that follows. It will be noted that Early Pearl is in the lead of the commercial varieties. The high yields obtained with 5 new varieties bred at the Station and tested in tenth acre plots for the first time make it hopeful that one or more of these may prove superior to Maine 340 which has in favorable years given the highest yield and stood up the best of any variety grown at Highmoor Farm. Early Pearl and Minnesota 26 are excellent commercial varieties. The late maturing of the Early Pearl is not so objectionable in the central and southern parts of the State as it is in Aroostook County.

Yield Per Acre of Commercial Varieties of Oats Tested at Highmoor Farm 1917. Arranged in Order of Yield of Grain.

Variety	Yield per Acre	
	Grain bushels	Straw pounds
Maine #1667	69.0	3032
Maine #1741	66.5	2512
Maine #1479	64.0	2792
Early Pearl	58.3	2728
Maine #1628	58.1	2340
Maine #1644	57.1	2532
Minnesota #26	55.8	2336
Maine #1641	53.8	2269
Irish Victor	53.7	2353
Maine #355	53.2	2279
Maine #351	52.9	2128
Maine #337	52.0	2025
Maine #281	49.8	1896
Maine #340	49.7	2098
Maine #1659	48.8	1790
Gold Rain	48.3	2043
Banner	48.2	1908
Maine #1054	44.6	2101
Maine #1640	39.0	1872

SOIL TEST EXPERIMENT AT AROOSTOOK FARM.

Aroostook County, and particularly the part along the Aroostook River, has two characteristic soils that are used for cropping. These grade more or less from one into the other but nevertheless they are 2 well marked types. The best and most abundant potato soil, which occurs where the hard wood growth flourished, has been named by the United States Department of Agriculture's Bureau of Soils as Caribou Loam. This by imperceptable gradations shades off into a dark brown or gray soil where the land was originally covered with black growth (conifers). To this soil the name Washburn loam was given. The principal soil type is the well drained "Caribou loam." This is the great potato soil of Aroostook County. Interspersing this is the poorly drained inferior "Washburn loam." Originally these soils were similar in origin, but through the centuries of plant occupation they have become biologically different.

One of the fundamental things in field agriculture is a knowledge of the soil that is being worked with. Much has been learned of Caribou loam from the experience of the men who have been cultivating it for a generation. Chemistry, soil physics, soil bacteriology and a study of the fungous organisms also contribute to the knowledge of this soil. But important as these sciences are they chiefly serve to explain results obtained. There is one way—and only one way—to adequately test a soil and learn its fertilizer needs. And that is by growing the plants to be studied in the soil.

After careful consideration of the difficulties and the expense involved the Station Council decided that all things considered there was no one thing that could be undertaken on Aroostook Farm better calculated to add to the knowledge of the permanent agriculture of the County than a long term experiment with fertilizers. The crops and the soil type were easily decided upon. Potatoes, oats and clover are now and are likely to be for many years to come the 3 standing staple crops of the county. And Caribou loam is the best and most common type of soil of the county.

THE PLAN OF THE EXPERIMENT.

The investment of time and money was to be so large that 2 years of time looking over literature, consulting with the best soil experimenters by letter and by visits to their operations were used before the final plans were adopted. As these plans are necessarily a compromise and cannot include all that one could wish and as it is hoped that this investigation may extend over many, many years of time the considerations that led to the adoption of the plan are here given in considerable detail.

The soil can be studied by growing plants in pots and under conditions where the growing conditions—moisture, shade, and the like—are under control or by growing the plants in the field. While there are many advantages in the green house method, if only one of these methods can be employed, the advantages of growing the plants in the field offset its disadvantages.

In soil test experiments as heretofore conducted in this country and abroad the general plan has been to decide somewhat arbitarily the amount of plant food to be used per acre and then apply the nitrogen, phosphoric acid and potash, each by itself, in combinations of 2, and finally all 3 combined in these fixed amounts upon the different plots. The great weakness in this plan is that one assumes at the start that the amounts of the ingredients decided upon are the amounts best adapted to the crop. A more logical method would be to apply each ingredient to different plots in varying amounts from none up to a point far beyond the amounts that would be likely to prove beneficial. After careful consideration this plan was adopted

THE TRIANGULAR DIAGRAM.

The triangular diagram as suggested by Schreinmacher, which has been of great service to physical chemistry where both theoretical and practical consideration of percentage composition of 3 component parts are concerned, has been adapted by Schreiner* to investigations in plant nutrition where it is desired

—Oswald Schreiner

*Bureau of Soils, U. S. Department of Agriculture Bulletin 70, Botanical Gazette, Vol. 1, No. 1, and elsewhere.

to consider the 3 component parts, ammonia, phosphoric acid and potash, of a fertilizer mixture. It is possible to represent graphically any possible combination of mixtures of these 3 component parts by the use of an equilateral triangular diagram, as shown in figure 1.

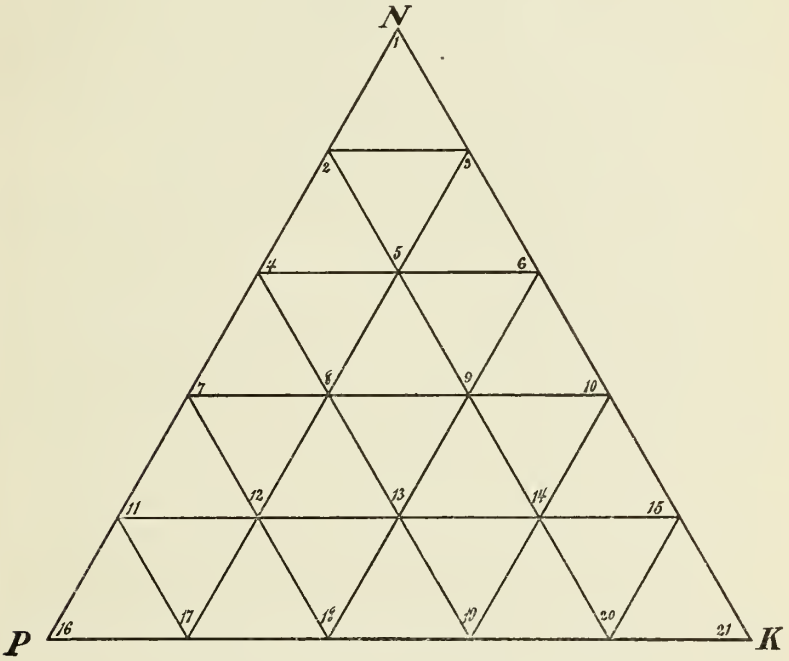

Fig. 1. The Triangular Diagram.

The extreme points of the angles represent 100 per cent respectively of the ingredients ammonia (nitrogen) prosphoric acid (phosphorus) and potash (potassium). Obviously each side of the triangle can be divided into as many equal parts as may be desired. Schreiner in his work in the green house with cultural solutions has been able to carry enough different combinations so as to divide the sides into tenths. That, however, makes 66 different combinations which is a far larger number than we could carry in this field test. Each side, therefore, is divided into fifths in the plan of the experiment here begun. And as explained beyond for the purpose of making the comparisons easier for the practical man familiar with usual fertili-

zer formulas, the 5-8-7 formula, which makes a total of 20 per cent of ammonia, available phosphoric acid and potash was used as a starting point. Hence, in the diagram here shown the extreme points of the triangle represent 20 per cent instead of 100 per cent as used by Schreiner. Although the fertilizer mixtures are in reality based upon the percentages expressed in terms of ammonia, phosphoric acid and potash the symbols N, P, and K for the elements nitrogen, phosphorus and potassium, which are the characteristic elements of these 3 constituents, are used in lettering. Wherever N is used in diagrams or text it refers to ammonia in available form, P refers to available phosphoric acid and K to water soluble potash.

The relation of the plots to each other is clearly seen by following the lines on the triangle. The maximum phosphoric acid (P) is at the left lower angle, the maximum potash (K) at the right lower angle and the maximum ammonia (N) is at the top of the triangle. From these points the different ingredients diminish. On all of the horizontal lines the phosphoric acid diminishes from left to right and the potash from right to left. On all of the lines inclined to the right the phosphoric acid decreases from bottom to top and the nitrogen decreases from top to bottom. On all of the lines inclined to the left the potash diminishes from the bottom to the top and the ammonia diminishes from the top to the bottom.

This plan calls for 21 plots. Obviously an indefinite number of plots could be introduced. To graduate on a scale of tenths would give finer distinctions but would treble the plots over a division into fifths as shown in the illustration and as adopted in this experiment. In the scheme here adopted combinations of the 3 fertilizers in the amounts indicated at the intersection of the lines were used. The actual percentage composition of the fertilizers are given in Figure 3 and others beyond. Obviously the plot at each apex and the 2 adjoining carries the maximum amount of ammonia, phosphoric and potash respectively, while the 6 central plots carry mixtures of all 3 constituents.

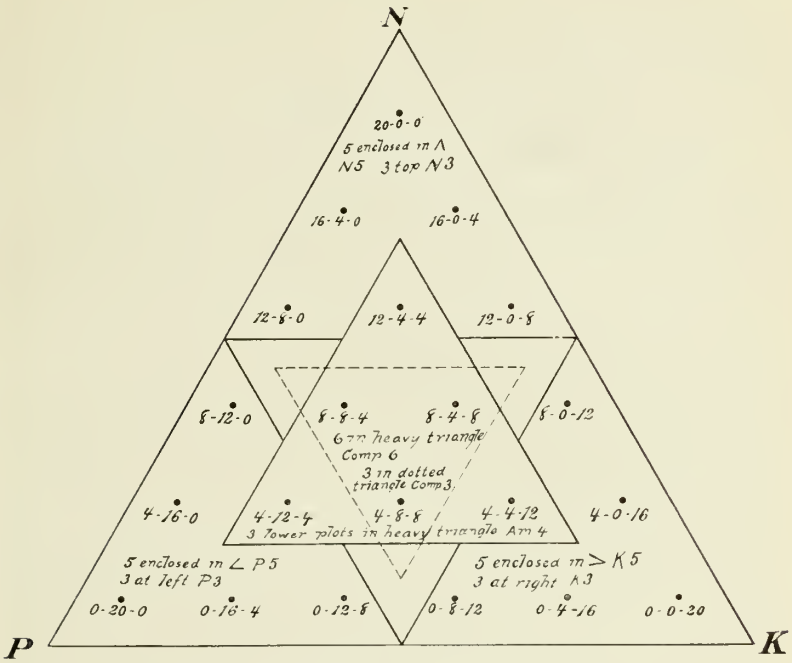

Fig. 2. The Relation of the plots in Groups.

Figure 2 shows diagramatically the relation of these plots in groups. The 5 plots enclosed in the Λ at the top of the figure are those in which ammonia predominates. The 3 plots nearest the top have the highest amounts of ammonia. In like manner the 5 plots enclosed in the < at the left at the bottom of the figure are those in which available phosphoric acid is the leading constitutent with the 3 highest nearest the angle. Included in the > at the right corner of the figure are those highest in potash. The 6 plots in the heavy triangle in the center of the figure contain all 3 of the ingredients and the 3 plots in the dotted triangle have them in somewhat more near to ordinary percentages than do the others. While the 3 lowest plots in the heavy triangle have the ammonia in the amount that is fairly common in many high grade fertilizers. As noted in the figure for convenience of reference in the text, these groups are called N5, N3, P5, P3, K5, K3, Comp 6, Comp 3 and Am4. This plan and diagramatic arrangement makes comparative studies of the different combinations easier and

more clearly shown than by any other method that has come to the attention of the writer.

THE FERTILIZING MATERIALS.

In the field experiments at Aroostook Farm with potatoes a 5-8-7 fertilizer or one that carries 5 per cent of ammonia, 8 per cent of available phosphoric acid and 7 per cent of potash has been used at the rate of 1200 pounds per acre. The same formula at the rate of 300 pounds per acre is used when seeding to oats and at the rate of 150 pounds per acre as a top dressing on mowing fields. Obviously a 5-8-7 fertilizer carries 20 per cent of plant food. This amount of 240 pounds is absurdly high and it was, therefore, taken as a maximum in the scale so that on the diagram where ammonia is shown as 20 per cent it represents 240 pounds of ammonia. This amount of ammonia would be furnished by 4800 pounds of a 5-8-7 fertilizer.

The ammonia is one-third in the form of ammonium nitrate and two-thirds in the form of sulphate of ammonia. The phosphoric acid is in the form of acid phosphate. The potash is all water soluble and is being applied during the war in the form that can be obtained. In 1917 it was in the form of sulphate.

The weights of ammonia, phosphoric acid and potash applied to each plot when the crop is potatoes is shown in the table that follows.

Application of Fertilizers Per Acre for Potatoes.

Treatment No.	Ammonia	Phosphoric Acid	Potash
1	0	240	0
2	0	192	48
3	48	192	0
4	0	144	96
5	48	144	48
6	96	144	0
7	0	96	144
8	48	96	96
9	96	96	48
10	144	96	0
11	0	48	192
12	48	48	144
13	96	48	96
14	144	48	48
15	192	48	0
16	0	0	240
17	48	0	192
18	96	0	144
19	144	0	96
20	192	0	48
21	240	0	0

For the 1-40 acre plots these amounts are divided by 40. These amounts are further reduced for application to oats by dividing by 120 and for application to grass by dividing by 240.

It was also desired to compare the usual potato formulas of 5-8-7 and 3-8-10 goods, insoluble phosphate rock in the form of finely ground floats with acid phosphate, and nitrogen in the form of dried blood and in tankage with the mineral nitrogen used in the soil test. These 5 additional plots with 6 check plots increase the number of plots to 32.

Field Arrangement of Plots.

It was thought that to overcome lack of uniformity in soil each plot should be in triplicate. This makes a total of 96 plots. As potatoes are the important cash crop of Aroostook County it seemed important that potatoes should be grown annually. As it was prohibitive to increase the number of plots much above 100 because of the cost of caring for a larger number, it was decided to grow the plots in a 3 year rotation of potatoes, oats and clover. This plan not only gives a potato crop each year but it makes the experiment better in that the effects of unfavorable weather conditions of any single year are minimized. The field selected for the location of the plots contains about 5 acres. It is isolated from the other cultivated fields on the farm. It has a gentle slope toward the west.

The plots are in 3 series: A, consisting of 33 plots, one extra check plot being added to this series, B, 32 plots and C, 32 plots. The several plots in each series are separated by pathways 33 inches wide running lengthwise and 36 inches wide running crosswise, while the different series are separated by roadways 6 feet in width, running lengthwise. The arrangement of the plots in the field is shown in Figure 3 on page 24.

For convenience of reference the plots are numbered by row and by plot. Thus Plot 11 is the first plot in the first row, while plot 36 is the sixth plot in the third row.

Outline of the Experiment in 1917.

The field was in potatoes in 1914 and fertilizer was used at the rate of 1500 pounds per acre of a 5-8-7 fertilizer. In 1915, it was seeded to timothy and oats.

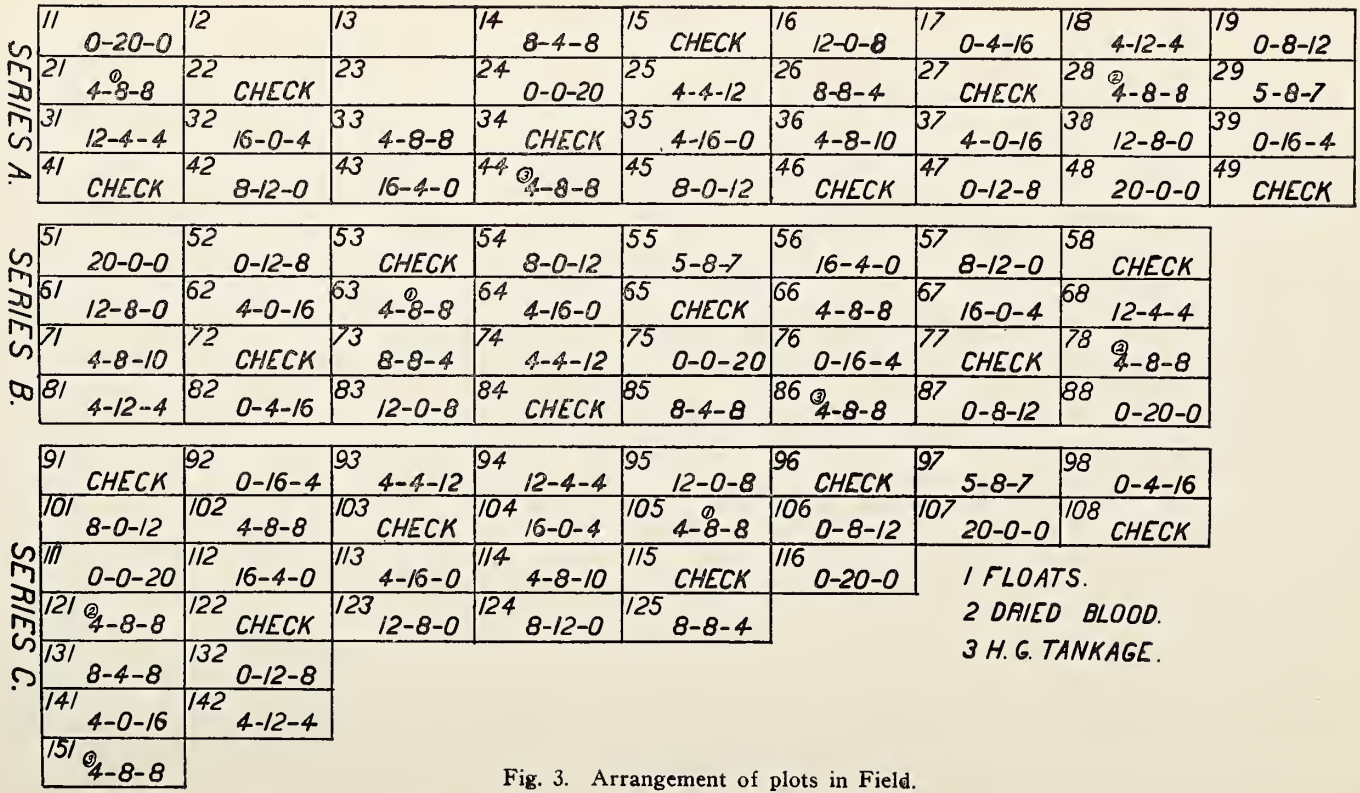

Fig. 3. Arrangement of plots in Field.

The field was plowed shortly after cutting the grass in 1916. Early in the spring of 1917 the 97 plots required to carry on this experiment were surveyed, each plot being 1 rod wide by 4 rods long, or one-fortieth of an acre in area. The ingredients for the several fertilizer mixtures were weighed and thoroughly mixed by hand. To insure even distribution each lot and plot were subdivided into fourths for the application of the fertilizer.

SERIES A. POTATO PLOTS. 11-43.

In preparing these plots for planting, furrows were made 33 inches apart, thus giving 6 rows per plot. The fertilizer was distributed in these furrows on May 16 and planting was completed the same day. The seed used was of the Norcross variety. The pathways, running lengthwise, were also planted and the plants allowed to grow throughout the season. By so doing the undesirable influence of marginal plants was, to a large exten, overcome. The pathways, running crosswise, were kept open. The plots were well cultivated and the plants thoroughly sprayed with bordeaux mixture and, nothwithstanding the prevalence of late blight throughout Aroostook County, hardly a trace of this disease could be found on the vines.

The variation in vine color, due to the differences in fertilizer mixtures, on these plots was very striking, ranging from a very light to an extremely dark green. The vines were green and vigorous until killed by frost.

The plots were harvested on September 22 and 24. The tubers were clean and free from rot. The yields are given in the table on page 26.

SERIES B. OAT PLOTS. 51-88.

Fertilizer was applied broadcast on these plots May 21 and planting completed the same day. Maine 340 oats were sown at the rate of 14 pecks per acre and a mixture of equal parts of Red and Alsike clover seeded at the rate of 12 pounds per acre. The stand of both oats and clover was excellent, but the excessive rainfall, coming at the time when the oat seedlings were about 2 inches high, gave them a setback from which they did not recover during the season.

The plots were harvested on August 31. Each plot was threshed separately and record made of the yield in both grain and straw. The yields were very uneven, due to the uneven stand. They are here included merely as a matter of record and not for any immediate consideration.

SERIES C. CLOVER PLOTS. 91-151.

Fertilizer was applied broadcast on these plots May 21 and planting was completed the same day. A mixture of equal parts of Red and Alsike clover was used at the rate of 12 pounds per acre. An excellent stand was obtained. The crop on these plots was not harvested but was plowed under in the fall of 1917 in preparation for the next season's potato plots.

Soil Test Experiment. Series A Planted to Potatoes in 1917.

The table shows the number of the plots, the yields per plot and the calculated yields per acre. Each plot is one rod by four. They are arranged in rows 11-19, 21-29, etc.

Plot No.	Fertilizer[1]	Yield per Plot		Yield per Acre Hundredweight		
		Merchantable	Culls	Merchantable	Culls	Total
		lbs. oz.	lbs. oz.			
11	0-20-0	245—14	16— 0	98.3	6.4	104.7
12	Not planted					
13	Not planted					
14	8-4-8	342—15	13— 4	137.8	5.3	143.1
15	Check	266—10	16—14	106.7	4.0	110.7
16	12-0-8	335— 3	21— 4	134.0	8.5	142.5
17	0-4-16	240— 1	12— 2	96.0	4.8	100.8
18	4-12-4	308— 6	16— 3	123.3	6.5	129.8
19	0-8-12	212— 7	12— 1	85.0	4.8	89.8
21	4-8-8[2]	335—10	12— 2	144.2	4.9	149.1
22	Check	312—15	18— 8	125.1	7.4	132.5
23	Not planted					
24	0-0-20	258—11	21—13	106.0	8.7	114.7
25	4-4-12	372— 7	20— 4	148.9	8.1	157.0
26	8-8-4	365—13	27— 7	146.3	11.0	157.3
27	Check	225— 5	24— 9	90.1	9.9	100.0
28	4-8-8[3]	299— 0	15—11	119.6	6.3	125.9
29	5-8-7	288— 7	25— 9	115.4	10.2	125.6
31	12-4-4	394— 5	19—14	157.7	8.0	165.7
32	16-0-4	392— 7	18— 2	157.0	7.3	164.3
33	4-8-8	411— 7	21— 9	164.6	8.6	173.2
34	Check	274— 0	22—10	109.6	9.1	118.7
35	4-16-0	340—12	22— 2	136.3	8.9	145.2
36	4-8-10	328— 5	23—11	131.3	9.5	140.8
37	4-0-16	306— 8	16— 8	122.6	6.6	129.2
38	12-8-0	347— 4	17—15	138.9	7.2	146.1
39	0-16-4	136—10	12— 4	54.7	4.9	59.6
41	Check	247—14	23—12	99.2	9.3	108.5
42	8-12-0	358— 5	21— 7	143.3	8.6	151.9
43	16-4-0	356— 2	30—15	142.5	12.4	154.9
44	4-8-8[4]	369— 1	18— 9	147.6	7.4	155.0
45	8-0-12	339— 1	34— 0	135.6	13.6	149.2
46	Check	228— 1	41—13	91.2	16.7	107.9
47	0-12-8	220— 7	16— 3	88.2	6.5	94.7
48	20-0-0	354—14	21— 6	142.0	8.6	150.6
49	Check	180—15	22—14	72.4	9.2	81.6

[1]The percentages of fertilizer are indicated in the order of ammonia, phosphoric acid and potash. Thus 0-20-0 means ammonia 0 per cent, available phosphoric acid 20 per cent and potash 0 per cent. Except as indicated otherwise in the footnote one-third of the ammonia is in the form of nitrate of soda and two-thirds as sulphate of ammonia; the phosphoric acid as acid phosphate and the potash in water soluble form. [2]Phosphoric acid in form of floats. [3]Ammonia in form of dried blood. [4]Ammonia in form of tankage.

Soil Test Experiment. Series B Planted to Oats in 1917.

The table shows the number of the plots, the yields per plot and the calculated yields per acre. Each plot is one rod by four.

Plot No.	Fertilizer[1]	Total Yield	Weight of Grain	Weight of Straw	Bushels per Acre
51	20-0-0	66	28	38	35.00
52	0-12-8	59	30	29	38.00
53	Check	68	33	35	41.00
54	8-0-12	34	19	15	24.00
55	5-8-7	40	21	19	26.00
56	16-4-0	36	19	17	24.00
57	8-12-0	44	17	27	21.00
58	Check	21	10	11	13.00
61	12-8-0	52	23	29	29.00
62	4-0-16	35	19	16	24.00
63	4-8-8[2]	44	24	20	30.00
64	4-16-0	25	13	12	16.00
65	Check	16	9	7	11.00
66	4-8-8	43	21	22	26.00
67	16-0-4	60	29	31	36.00
68	12-4-4	40	19	21	24.00
71	4-8-10	56	26	30	33.00
72	Check	38	20	18	25.00
73	8-8-4	47	23	24	29.00
74	4-4-12	41	22	19	28.00
75	0-0-20	23	12	11	15.00
76	0-16-4	47	23	24	29.00
77	Check	35	19	16	24.00
78	4-8-8[3]	28	14	14	18.00
81	4-12-4	58	27	31	34.00
88	0-20-0	35	18	17	23.00
		51	23	28	29.00
82	0-4-16	43	23	20	29.00
83	12-0-8	44	21	23	27.00
84	Check	50	23	27	29.00
85	8-4-8	36	20	16	25.00
86	4-8-8[4]	29	15	14	19.00
87	0-8-12				

[1]The percentages of fertilizer are indicated in the order of ammonia, phosphoric acid and potash. Thus 0-20-0 means ammonia 0 per cent, available phosphoric acid 20 per cent and potash 0 per cent. Except as indicated otherwise in the footnote one-third of the ammonia is in the form of nitrate of soda and two-thirds as sulphate of ammonia; the phosphoric acid as acid phosphate and the potash in water soluble form.

[2]Phosphoric acid in form of floats.

[3]Ammonia in form of dried blood.

[4]Ammonia in form of tankage.

Soil Test Experiment—Series A—Potatoes in 1917.

ARRANGED IN TRIANGULAR DIAGRAM.

The letters N, P and K indicate the parts of the triangle where ammonia, available phosphoric acid and potash are respectively at their maximum amounts. The upper numbers above each * are the plot numbers. The numbers arranged in threes and connected by - give the composition of the fertilizer used. The numbers below the * give the yields per acre ex-

pressed in hundredweights. The plots below the heavy dotted line are outside of the triangle. They are check plots and specially treated plots.

		N			
		48 20-0-0 * 151			
		43 16-4-0 * 155		32 16-0-4 * 164	
	38 12-8-0 * 146		31 12-4-4 * 166		16 12-0-8 * 143
42 8-12-0 * 152		26 8-8-4 * 157		14 8-4-8 * 143		45 8-0-12 * 149
	35 4-16-0 * 145		18 4-12-4 * 130		33 4-8-8 * 173		25 4-4-12 * 157		36 4-0-16 * 129	
11 0-20-0 * 105 P		39 0-16-4 * 60		47 0-12-8 * 95		19 0-8-12 * 90		17 0-4-16 * 101		24 0-0-20 * 115 K

15 0-0-0 * 111	22 0-0-0 * 133	27 0-0-0 * 100	34 0-0-0 * 119	41 0-0-0 * 109	46 0-0-0 * 108
49 0-0-0 * 82	29 5-8-7 * 126	36 4-8-10 * 141	21 4-8[1]-8 * 149	28 4[2]-8-8 * 126	44 4[2]-8-8 * 155

[1]Phosphoric acid in form of floats
[2]Ammonia in form of dried blood
[3]Ammonia in form of tankage

Discussion of Results.

This is designed as a long term experiment and very little can be learned from a single year's results. As stated above the oat yields were uneven largely because of the uneven stand due to seasonal causes. The detailed plot yields of the oats and straw are given in the table on page 27, and for the potatoes on page 26. The results in hundredweight for the potato yields are given in the triangular diagram on page 28.

Plot 39 showed lack of vigor throughout the season and the yields from 19, 29 and 49 were smaller than expected. These 4 plots are nearer the woods and it may be that detailed soil examinations that are to be made of all of the plots will show differences in soil type. There is no apparent reason for check plot 22 having the high yield that it gave.

Grouped by the plots at the points of the triangle and by the center plots the average yields are:

	Hundredweight per acre
Three ammonia plots N3 in diagram*	157
Five ammonia plots N5 in diagram	152
Three available phosphoric acid plots P3 in diagram	103
Five available phosphoric acid plots P5 in diagram	111
Three potash plots K3 in diagram	115
Five potash plots K5 in diagram	117
Three center plots Comp 3 in diagram	158
Six center plots Comp 6 in diagram	154
Three lower center plots Am4	153
Seven check plots	109

The small yield from plot 39, 0-16-4, is due to other cause than the fertilizer and the high yield on plot 35, 4-16-0, is doubtless due to the ammonia. Neglecting both of these does not affect the yield from the phosphoric acid corner as plot 11, 0-20-0, yielded 105 hundredweight.

The preponderance of ammonia is shown by arranging the results in the order of the percentage of ammonia in the fertilizer mixtures.

*See page 21

No ammonia 5 plots*	101 hundredweight per acre
Four per cent ammonia 5 plots	147 hundredweight per acre
Eight per cent ammonia 4 plots	150 hundredweight per acre
Twelve per cent ammonia 2 plots	152 hundredweight per acre
Sixteen per cent ammonia 2 plots	160 hundredweight per acre
Twenty per cent ammonia 1 plot	151 hundredweight per acre

*Omitting plot 39

But as is discussed beyond (page 350), it would not do to infer from this series of experiments a general proposition that Caribou loam is deficient in ammonia.

As phosphoric acid was not a limiting factor plot 21 in which the phosphoric acid is in the form of floats would be expected to give as it did a yield as high as the same formula with acid phosphate as the source of the phosphoric acid. Plot 44 in which the ammonia was in the form of tankage gave results (155 cwt.) as would be expected. The low yields of 126 hundredweight from plots 28 and 29 may be due to soil or subsoil differences.

EFFECT OF OMITTING POTASH FERTILIZATION UPON THE OAT CROP.

Owing to the shortage of potash caused by the war it is very important to have as much information as possible regarding the value of this element for various crops. In 1915 the Maine Agricultural Experiment Station began a series of experiments at Aroostook Farm with the object of determining the value of potash for potatoes. In general these results have shown that there is sufficient available potash in Aroostook soils to mature a profitable crop of potatoes. Nevertheless the addition of relatively small amounts of potash has resulted in a marked increase in yield.

In order to obtain some information relative to the value of potash for oats experiments were begun at both of the experiment farms in 1916. The stand was so poor and uneven because of heavy rains that no records of importance were obtained at Highmoor Farm in 1916. The results obtained at Aroostook Farm in 1916 were published in Bulletin 260. The experiment was continued at both farms in 1917. The results are given in the tables that follow.

Table Showing Yields Per Acre in No Potash Experiment with Maine 340 Oats on Aroostook Farm 1917.

Plot No.	Amount of Potash	Straw Pounds	Grain Bushels
714	None	2110	43.4
719	None	1080	33.8
Average		1595	38.6
715	None + Common Salt	2020	46.2
720	None + Common Salt	1220	36.7
Average		1620	41.5
716	2 per cent potash	1580	38.1
721	2 per cent potash	1204	37.6
Average		1392	37.9
717	5 per cent potash	1880	44.4
722	5 per cent potash	1670	38.4
Average		1775	41.4
718	7 per cent potash	2230	45.9
723	7 per cent potash	1420	43.1
Average		1825	44.5

Table Showing Yields Per Acre in No Potash Experiment with Maine 340 Oats at Highmoor Farm 1917.

Amount of Potash	Straw Pounds	Grain Bushe's
No Potash	1913	45.3
No Potash + Common Salt	1817	43.3
3 per cent Potash	1786	41.4
5 per cent Potash	1517	38.4
7 per cent Potash	1338	31.6

Average Yields Per Acre in No Potash Experiment with Oats in 1916 and 1917.

Amount of Potash	Bushels of Grain		
	Average	1916	1917
None	55	68	41
None plus salt	55	67	42
2 per cent	52	65	39
5 per cent	54	68	40
7 per cent	55	69	40

There are no appreciable differences in the yields with the different treatments. Evidently on Aroostook Farm it is indicated by these trials that potash is not a limiting factor in growing oats. The stands were too uneven at Highmoor Farm to warrant conclusions. It is not probable that the addition of potash explains the reduced yields that apparently uniformly followed its increased application at Highmoor Farm.

EFFECT OF OMITTING POTASH FERTILIZATION UPON THE POTATO CROP.

Since the introduction of potash in commercial fertilizers in the early seventies of the last century, many experiments have been made and many treatises written showing the value of potash in crop growing. The experimental data on growing crops without potash are very few.

Potatoes are the chief cash crop grown in Maine. It is of first importance for the growers to have what facts are available relative to the likelihood of obtaining a crop in 1918 without the application of potash. Foreseeing the possibility that, with the continuance of the war, very little potash would be available for fertilizers, the Maine Agricultural Experiment Station began in 1915, at Aroostook Farm, a series of experiments to determine the effect of different amounts of potash. The results obtained in 1915 were published in Bulletin 246. Those for 1916 were published in Bulletin 260.

Five different mixtures were used. In each case the fertilizers contained 5 per cent of ammonia of which one-third was in the form of nitrate of soda, and 8 per cent of available phosphoric acid. The potash varied as follows: On one plot there was no potash. The next plot also had no potash but common salt was mixed with the fertilizer at the rate of 300 pounds of salt per acre. The salt was used to see whether this would aid in freeing potash already in the soil and not in a form available for plant food. The fertilizer for the remaining 3 plots contained respectively 3 per cent, 5 per cent and 8 per cent potash. In each case the fertilizer was applied at the time of planting, at the rate of 1500 pounds per acre. Each plot was slightly less than one-half acre in area. The area of each plot was obtained by actual measurement and the yields are based on the weighed potatoes from each plot. Norcross potatoes were used for seed. Other than in respect to potash all plots were treated exactly alike. The land used for this experiment had been in sod for 2 years. The experiment was made in duplicate and is separately reported.

Yield Per Acre in No Potash Experiment with Potatoes. 1917.

Plot No.	Amount of Potash	Merchantable			Culls		
		Cwt.	Bbls.	Bus.	Cwt.	Bbls.	Bus.
	SERIES 1						
755	None	131.0	79.4	218.4	4.1	2.5	6.9
756	None + Salt	136.0	82.4	226.8	4.6	2.8	7.7
757	3 per cent Potash	135.3	82.0	225.5	3.1	1.9	5.2
758	5 per cent Potash	130.8	79.3	218.8	2.6	1.6	4.4
759	7 per cent Potash	138.6	84.0	231.0	2.5	1.5	4.1
	SERIES 2						
760	None	139.5	84.6	232.7	4.0	2.4	6.6
761	None + Salt	144.0	87.3	240.1	3.6	2.2	6.1
762	3 per cent Potash	149.3	90.5	248.9	3.5	2.1	5.8
763	5 per cent Potash	157.4	95.4	262.4	3.8	2.3	6.3
764	7 per cent Potash	160.4	97.2	267.3	3.8	2.3	6.3

The yields for the 3 years 5 series are summarized in the table that follows.

No Potash Experiment with Potatoes. 1915-1916-1917. Yield in Hundredweight Per Acre.

Amount of Potash	1915	1916		1917		Average
		Series 1	Series 2*	Series 1	Series 2	
None	182	172	198	131	140	156
None + Salt		193	200	136	144	158
3 per cent Potash	191	254	193	135	150	182
5 per cent Potash	191	254	191	131	157	183
8 per cent Potash	198	244	226	139	166	185

*In this series the potatoes followed potatoes. Omitted from average.

From the results of these 4 trials in 3 seasons on sod land the following tentative conclusions may be drawn: The addition of 300 pounds of common salt per acre made a small but uniform increase in yield. The addition of as little as 45 pounds (1500 pounds of 3 per cent goods) per acre of potash uniformily increased the yield of potatoes and profitably. That on Aroostook Farm soil nothing was gained by a larger application. That good yields were obtained without any potash. It will also be noted that in the soil test experiment (page 17) that nitrogen and not potash seems to be the limiting factor in potato production on Aroostook Farm.

THE POTATO CROP IN ITS RELATION TO SOIL AND FERTILIZER.

If one could only know the exact amount of plant food that a given crop could avail itself of in a given soil the question of application of plant food in the form of a fertilizer would be much simplified. Caribou loam is the potato soil of Aroostook County. Interspersed with it are patches of greater or less extent of the much less desirable Washburn loam. It is perfectly easy to select typical Caribou loam soils. Will the same fertilizer give the same results—other conditions being as equal as may be—on different fields with this type of soil?

This Station has made a series of studies upon the need of potash to grow potatoes upon Caribou loam. In 1917 the division of Soil Fertility Investigation and the division of Cotton, Truck and Forage Crop Disease Investigations of the Bureau of Plant Industry of the U. S. Department of Agriculture in searching for the probable cause of the "new disease" of potatoes noticed in 1916 made a series of trials with fertilizers using the triangle scheme that this Station has adopted from them and which is discussed on pages 23 to 26 of this Bulletin. They were interested in comparing results obtained on Caribou loam with those obtained on Washburn. It is interesting to compare the results they obtained on Caribou loam with those obtained by this Station on Aroostook Farm Caribou loam. All of the experiments were near Aroostook Farm and had the same weather conditions. The results from Aroostook Farm are given in the column headed A. The other letters refer to the tests made by the Department of Agriculture but the letters used are merely distinguishing but not identifying. They are grouped according to the triangle diagram. (See page 21).

Fertilizer treatment	Hundred weight per acre of potatoes			
	A	N	S	Y
Three ammonia plots	157	95	93	39
Three phosphoric acid plots	103	109	85	100
Three potash plots	115	123	116	79
Seven check plots	109	87	94	53
Six center (Complete) plots	154	125	159	120

It is evident as discussed above that ammonia is the limiting factor on the soil test experiment field of the Station at Aroostook Farm. Not only does ammonia give a higher result than either phosphoric acid or potash but it gives a yield equal to that obtained with a complete fertilizer. The yields from the different plots N show potash as the limiting factor but with some response from phosphoric acid and ammonia. The yields obtained with potash equal those from the complete fertilizer plots. With S potash gives increased yields while ammonia and phosphoric acid do not. But the yields from the 3 potash plots are much lower than from the complete plots. The yields obtained by Y are not helped by ammonia, are helped some by potash and markedly by phosphoric acid. But the complete outyields the phosphoric acid.

These 4 fields all with Caribou loam and situated near each other in the Aroostook Valley indicate different values for each of the fields. On A ammonia is the essential. On N it is Potash that is needed. On S potash is the valuable constituent but it needs a complete fertilizer to bring the maximum yield. While on Y phosphoric acid doubles the yield, ammonia does not affect the yield and potash adds 50 per cent to the yield. From this evidence on A one would expect ammonia to be profitable. On N potash will be needed for results. On S potash pays but the complete fertilizer gives the maximum yields. On Y both potash and phosphoric acid are needed to produce the maximum yields and ammonia has no effect.

It is needless to say that no definite conclusions can be drawn from these results. They are only one year's results and as explained on page 18, it is planned to continue this work through a long period of years.

POTATOES GROWN AT AROOSTOOK FARM ON FERTILIZERS CONTAINING AMMONIA (NITROGEN) IN DIFFERENT FORMS.

A few years ago there was quite a general failure of the crop of potatoes in Aroostook County where a certain brand of fertilizer was used. This fertilizer was analyzed by the Station chemists and found to be high grade. While it was not quite up to its guaranty in some particulars it did carry enough nitrogen, phosphoric acid and potash to more than grow a good crop of potatoes. This fertilizer carried none of its nitrogen in the form of nitrate of soda, but it was all in the form of sulphate of ammonia and high grade organic materials. This led to the stronger reaffirming of the position which the Station had taken relative to the use of nitrate nitrogen in the potato crop. In earlier publications it has been pointed out that the potato makes its demands for nitrogen early in the season and that in the cold, late springs so common in Aroostook County, the crop demands that part of the nitrogen should be immediately available. For this reason the Station has strongly urged that about one-third of the nitrogen in a potato fertilizer be nitrate nitrogen.

In the process of making gas and coke from coal there is developed a large amount of sulphate of ammonia, which in many coke and gas plants is still going to waste. In some plants this now is being conserved and many thousand tons of sulphate of ammonia are thus obtained each year. With the increasing use of high grade organic nitrogen for food of animals, the price of tankage has been going higher and higher year by year. It is, of course, desirable, if it can be done, that as much as possible of this sulphate of ammonia, which is a comparatively cheap source of nitrogen, be used in Maine fertilizers.

Because of these facts, arrangements were made to begin in 1914 a series of experiments to run over a period of several years. The "base" which was used in these goods was made by the wet process, whereby nitrogen from rather low grade goods is made as available as from high grade goods. The available

phosphoric acid was furnished in the form of acid phosphate and the potash in the form of sulphate of potassium. The fertilizer was free from chlorides so as to preclude the possibility of the formation of poisonous ammonium chloride. The base carried approximately one-third of the nitrogen that went into the formula. The remainder of the nitrogen was furnished in the form of nitrate of soda and sulphate of ammonia, as indicated in the following plan:

Plot 1. Basal mixture and 2-3 of the nitrogen in form of nitrate of soda.

Plot 2. Basal mixture and 2-3 of the nitrogen in form of sulphate of ammonia.

Plot 3. Basal mixture and 1-3 of the nitrogen in form of nitrate of soda and 1-3 in form of sulphate of ammonia.

Plot 4. Basal mixture and 1-3 of the nitrogen in form of high grade organic and 1-3 in form of nitrate of soda.

Plot 5. Basal mixture and 1-3 of the nitrogen in form of high grade organic and 1-3 in form of sulphate of ammonia.

In each case the finished fertilizer analyzed 5 per cent ammonia, 8 per cent available phosphoric acid and 7 per cent potash. In each year the fertilizer has been applied in the planter at the rate of 1500 pounds per acre. Other than the fertilizer used the plots were planted, cultivated, sprayed and cared for in all particulars alike. In each year duplicate plots each about one-half acre in area have been grown with each mixture.

The results for 1914 and 1915 are reported in detail in Bulletin 246 and those for 1916 in Bulletin 260. The detailed results for the experiment in 1917 are given in the table that follows. The results for the 4 years the experiment has been conducted are given in the table below.

Growing Potatoes with Application of Different forms of Nitrogen Yield of Potatoes Per Acre.

Plot No.	Treatment	Merchantable			Culls		
		Cwt.	Bbls.	Bus.	Cwt.	Bbls.	Bus.
765	⅔ Nitrate of Soda	143.9	87.2	239.8	4.5	2.7	7.4
770	⅔ Nitrate of Soda	135.9	82.4	226.6	2.5	1.5	4.1
Average		139.9	84.8	233.2	3.5	2.1	5.7
766	⅔ Sulph. of Ammon.	140.3	85.0	233.7	4.6	2.8	7.7
771	⅔ Sulph. of Ammon.	143.2	86.8	238.7	3.5	2.1	5.8
Average		141.7	85.9	236.2	4.5	2.5	6.8
767	⅓ Nit. of Soda ⅓ Sulph. Ammon.	134.5	81.5	224.1	3.1	1.9	5.2
772	⅓ Nit. of Soda ⅓ Sulph. Ammon.	145.0	87.9	241.7	2.8	1.7	4.7
Average		144.8	84.7	241.3	2.9	1.8	4.9
768	⅓ Nit. of Soda ⅓ Organic	132.0	80.0	220.0	3.5	2.1	5.8
773	⅓ Nit. of Soda ⅓ Organic	143.7	87.1	239.5	3.1	1.9	5.2
Average		137.9	83.6	229.8	3.3	2.0	5.5
769	⅓ Sulph. Ammon. ⅓ Organic	136.6	82.8	227.7	3.7	2.3	6.3
774	⅓ Sulph. Ammon. ⅓ Organic	150.0	90.9	250.0	3.0	1.8	5.0
Average		143.3	86.8	238.9	3.4	2.1	5.7

Growing Potatoes with Application of Different forms of Nitrogen in 1914-1915-1916 and 1917. Yield in Hundredweight Per Acre.

Treatment	1914	1915	1916	1917	Average
⅔ Nitrate of Soda	198	186	231	140	189
⅔ Sulphate of Ammonia	182	198	231	142	188
⅓ Nit. Soda ⅓ Sulph. Ammon.	191	196	226	145	190
⅓ Nit. Soda ⅓ Organic	198	183	231	138	188
⅓ Sulph. Ammon. ⅓ Organic	182	180	236	143	185

From the results of these trials it appears that there is little choice in the form that nitrogen is used on potatoes in Aroostook County and that the supposition made in the first paragraph of this report has not held true at Aroostook Farm in the past 4 years. The experiment is to be continued at least one more year.

PLANT BREEDING AT AROOSTOOK FARM IN 1917.

OATS.

Oat breeding experiments have been conducted at Aroostook Farm since 1914. This work has been directed toward developing new and improved varieties of oats which would be better adapted to the conditions in the northern part of this State than those now grown. The work has been carried on along three principal lines: (1) variety tests, (2) pure line selections and (3) hybridization work.

Comparative trials of commercial varieties more popular in the central part of the State, were begun in 1914, and were continued in 1915 and 1916. The detailed results of these experiments were published in Bulletins 246 and 260. These results indicate that certain varieties of oats which are well adapted to the conditions in the central and southern part of the State are not suited to Aroostook conditions. It was proposed to continue these variety tests for a number of years. Owing, however, to the movement for increased production of farm products in connection with the war emergency, it was deemed advisable to temporarily discontinue the variety test in 1917, and seed the acreage available for small grains to Maine 340 which has proven to be one of the best varieties so far obtained for Aroostook County.

As a further means of developing new and better varieties the work with pure line selections was undertaken. The principle of this work is based on the isolation of prepotent individual plants out of standard commercial varieties. In 1914 several hundred individual plants were selected from varieties known to have been grown in Aroostook for several years. In 1915 the seed from each of these plants was sown in a separate row in the nursery or breeding garden. Thus the plants of each row were the offspring of a single, self-fertilized plant of the year before, and represented what is called a "pure line." Careful notes were taken on each row, and those that showed the most desirable characters were harvested and threshed, each row by itself. In 1916 the seed of each of the most promising rows was planted in 5 replicate plots each 1-2000 acre in area. The rather high number of replications offered a safer basis

in the subsequent analysis of the merits of each pure line than when only one or 2 plots to each strain are used. In the latter case the real differences in the character of a strain may be obscured by soil irregularities. Out of the 100 strains grown in 1916 only 20 pure lines were continued in 1915 in 1-20 acre plots. In 1918 about 10 of these pure lines will be tested and propagated under field conditions using triplicate plots 1-10 acre to each strain.

The hybridization work with oats, while primarily conducted in the interest of scientific investigations regarding the mode of inheritance of the various characters of oats, promises also results of commercial value. The relatively short growing season prevailing in Aroostook has led the farmers to grow early maturing oat varieties. The majority of these early varieties, however, are light yielding oats. Consequently, in the breeding work the attempt is being made to combine, through crossing, the high yielding qualities of medium late and late varieties with the character of earliness of the Aroostook grown varieties. Since 1915 several crosses have been made which will be tested in 1-2000 acre plots in 1918. In addition to hybrid oats originated in the breeding work at Aroostook Farm, oat crosses between varieties which appear promising for Aroostook conditions, have been taken from Highmoor Farm, and tested in garden rows and small plots at Aroostook Farm.

Wheat.

The object of this work is to secure a wheat of good quality. The quality of wheat is principally determined by the milling or flour yield and the flour strength. The flour strength is closely correlated with the gluten content of wheat, and is measured by the volume and texture of the bread loaf produced from the flour. The hard wheats furnish, as a rule, flour of high strength. The majority of Aroostook grown varieties of wheat develop soft grain producing flour of inferior grade. Wheats imported from the Northwest after one season's growth in Aroostook lose their character of "hardness". These conditions have led the Station to undertake some definite breeding work with wheat at Aroostook Farm. The principal aim of this work is to secure a hard wheat that would maintain its hardness under Aroostook conditions. The methods followed

in this work include pure line selections and hybridization work.

Since the imported northwestern wheats showed such a rapid deterioration and lack of adaptation it was thought advisable to confine the selection work chiefly to Maine grown varieties of wheat. In 1915 a large number of plants were selected from commercial wheat varieties grown at Aroostook Farm as well as on several farms in the County. The seed from individual wheat ears was planted in garden rows in 1916 giving rise to about 300 pure lines of wheat. The seed of each row was harvested separately and tested in the laboratory with a grain tester for hardness. About 100 pure lines were retained and continued in duplicate 1-2000 acre plots in 1917. Each of the pure lines grown in 1917 furnished enough seed so that protein analyses could be made with each line. The analyses show a marked variation in the protein content which, however, is generally quite high. Using these analyses and the field notes as a basis a further scrutiny of these pure lines of wheat will be made and the inferior strains eliminated. Several of these lines are very promising and will be propagated in 1-80 acre plots in 1918. It may be of interest to state that the most promising strains represent selections from Maine grown wheats. In the hybridization work with wheat several crosses have been made between hard northwestern and Aroostook grown high yielding wheats.

TIMOTHY IMPROVEMENT.

The hay crop is an important source of income in Aroostook County. The yield of the hay crop as of any other crop can be improved by breeding more productive strains. In this State the merchantable hay crop is chiefly made up of timothy. It was thought desirable to undertake some work with a view toward improving the commercial timothy seed grown in this State. Selection of most promising plants and their vegetative propagation by means of bulbs or slips is the method followed in this work.

Seed was collected from individual heads of vigorous tall culms borne by good plants growing in meadows and fields. The seed was planted in flats each row representing the progeny of a single head. After the plants produced the third leaf they were transplanted into the grass garden. The seedlings from

one head were planted in a row by themselves. Owing to the short growing season in Aroostook the starting of the seedlings and their transplanting is done in the spring, as in the fall the seedlings would not become well rooted before the winter comes on. In the second summer the best individual plants were selected, dug out and propagated by bulbs or slips giving rise to clonal* strains or varieties. As the timothy plant is a cross-fertilizing plant it is desirable to interpose between the selection of best individuals and their propagation a period of purifying of these individuals by self-fertilization in order to eliminate all possible hybrid mixtures and secure pure strains that breed true. The clonal varieties from single timothy heads are being tested in small plots at Aroostook Farm, and the seed of the ultimate best strains will be retained. In the summer of 1918 these plots will furnish enough seed to plant fairly large plots.

Strawberries.

Small fruit culture is only slightly followed in Aroostook County. The wild strawberry flourishes. Because of many inquiries indicating interest on the part of Aroostook people in small fruits the Station Council in the spring of 1916 decided to begin investigations with strawberries at Aroostook Farm. This work is being taken up along the same general lines of the other plant breeding work at the farms. Standard commercial varieties are tested to learn which of these are best adapted to Aroostook conditions and also to furnish plants for breeding work both by selection and by hybridization.

In the spring of 1916, 15 varieties of strawberry plants were purchased. When they reached the farm 2 lots were so badly wilted that they could not be revived. The remaining 13 varieties consisted of 11 standard and 2 of the everbearing type. Ten additional varieties were added to the testing plot in 1917.

The yields per acre and the length of the fruiting season for the varieties set out in 1916 which fruited in the summer of 1917 are given in the table that follows. The 2 everbearing varieties are marked with a * and the 2 varieties having im-

*A clon is a plant group the members of which have been grown from an original stock but which do not come true from seed.

perfect flowers are marked with a †. Glen Mary while classed as a perfect variety has weak pollen and should be set with perfect varieties in order to insure pollination. That is it should, in our experience, be treated as though it bore imperfect flowers.

Data on Strawberries Fruiting at Aroostook Farm in 1917.

Variety	Quarts per Acre	Fruiting Season First Picking	Duration in Days
Pearl	282	July 28	7
Chesapeake	571	July 17	16
Marshall	712	July 16	12
Superb*	1960	July 11	21
William Belt	2345	July 16	17
Magic Gem	2614	July 17	16
Progressive*	2817	July 9	17
Early Ozark	2940	July 11	15
Premier	2971	July 11	22
Sample†	3071	July 16	17
Dr. Burrill	3898	July 11	22
Glen Mary	4055	July 16	17
Crescent†	4719	July 13	23

*Everbearing. †Pistillate varieties.

Owing to the danger of early frost in this section it is doubtful if the everbearing varieties can be depended upon for more than the ordinary spring crop. During the season of 1917 no ripe fruit was produced by these plants later than August 2. They were, however, heavily laden with immature fruit when further progress toward maturity was stopped by frost.

Several of the native wild strawberry plants, so abundant in Aroostook, were placed in the plot for breeding purposes. While they responded to cultivation in so far as producing a heavy growth of vine is concerned, the yield of fruit was extremely small and but little increase in the size of berries over those produced under natural conditions was observed.

The results from a single year's test are not conclusive but it would be unwise to set for fruit in Aroostook County any of the varieties like the Pearl, Chesapeake or Marshall that gave small yields with a short fruiting season.